

Environmental Effects of Dredging Technical Notes

CE SEDIMENT COLLECTION AND ANALYSIS METHODS

PURPOSE: This note summarizes responses to a recent survey of US Army Corps of Engineers (CE) sediment collection and analysis methods used in conjunction with planning dredging and disposal operations. The survey was designed to provide an overview of sediment collection and analysis programs and how these programs are conducted. Information gathered from the survey will be used to generate topics of discussion for a meeting to be held in June 1987 on sediment-analysis cost reduction. The survey and the meeting are part of a multi-year CE effort to reduce the overall costs associated with collecting and analyzing sediment samples.

BACKGROUND: Sediment collection and analysis prior to dredging can be extensive and costly. Results of the analysis can often affect the fate of a dredging project since disposal decisions are based on many factors that include the types and concentrations of contaminants in the sediment, sediment toxicity, and bioavailability of contaminants. Selection of sampling locations, sampling techniques, number of samples collected, and necessary tests should represent a careful balance between the needs of the dredging project and reasonable cost.

Cost control must encompass all aspects of sampling and analysis. The first step is to review any data previously obtained from the vicinity of the dredging project and to ensure consideration has been given to all information that may impact the development of the sample-collection plan. Past contaminant histories from other dredging projects in the area can indicate that there are specific contaminants in the sediment. This information could be used to determine the optimal number of samples to collect for sediment characterization.

Analytical costs are directly related to the number of samples analyzed and the parameters for which each sample is analyzed. Obtaining samples is a minor portion of the overall sampling and analytical cost on most projects. Therefore, it is common practice for more samples to be collected than are initially analyzed. The additional samples may be archived for possible future chemical analysis but must be stored and cared for properly. Biological tests and chemical tests other than bulk or total chemistry analyses cannot be performed on sediment samples that have been archived because chemical changes occur in archived sediment that may affect the accuracy of results. Should the need for biological testing be identified after

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the initial sample collection, additional samples would have to be collected, increasing sampling costs.

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Description of Survey Techniques

Thirteen CE Districts and one CE Division (FOAs) were surveyed by telephone. The FOAs surveyed are shown in Figure 1. Each FOA contacted has

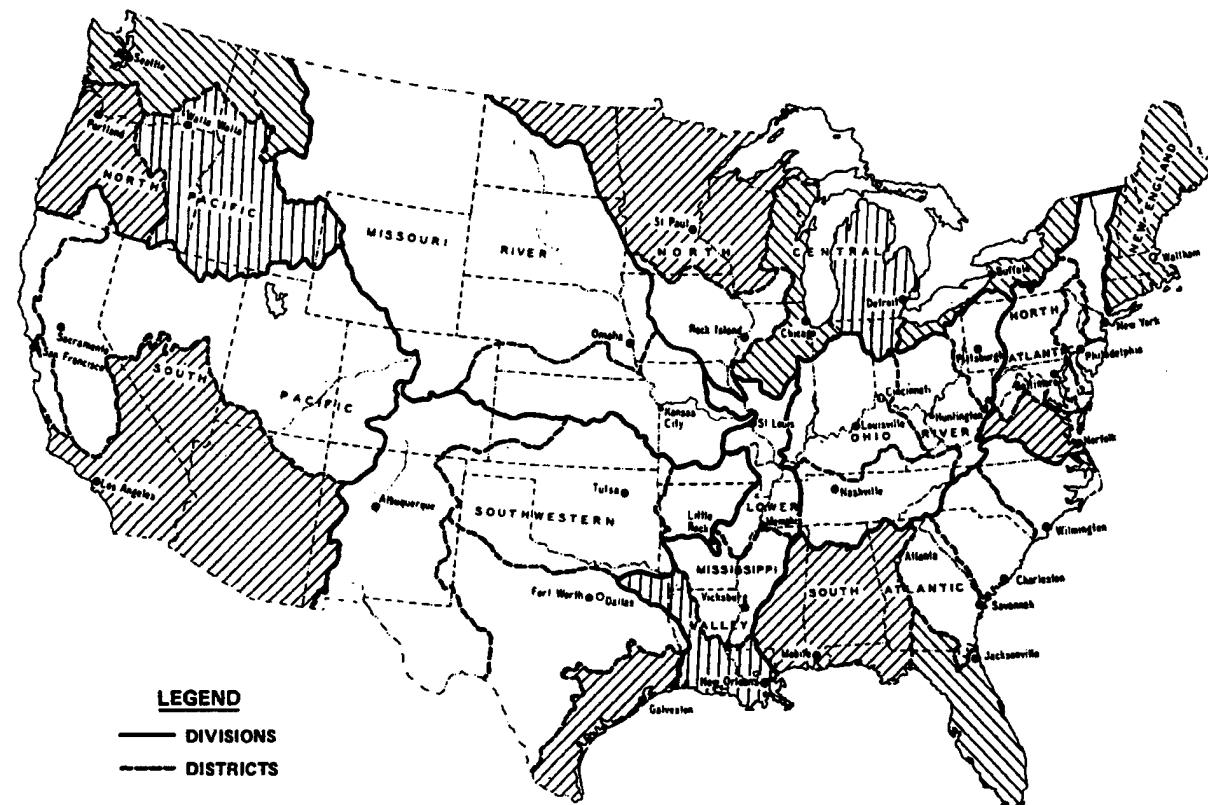


Figure 1. FOAs contacted in survey (cross-hatched areas) of CE sediment sampling and analysis methods

significant dredging and disposal operations. Responses were solicited from individuals in the FOAs whose responsibilities included planning, conducting, or managing sediment sample collection and analysis. Responses to the survey have been consolidated in Table 1.

Interpretation of Survey Responses

Question: What types of navigable waters comprise the majority of dredging projects within FOA's jurisdiction?

Response: Respondents represented FOAs engaged in maintaining the spectrum of waterways managed by the CE. Many of the FOAs surveyed have responsibility for maintaining more than one type of waterway. This suggests that FOAs must be flexible in their approach to sediment sampling due to variations in the land use surrounding the project area and in the hydrology of the waterways.

Remarks: Any cost-reduction guidelines and methods must recognize the site-specific differences involved in managing dredging operations.

Question: What approach do you take to design a sediment-sampling plan?

Response: All FOAs responded that the design of a sediment-sampling plan was strongly influenced by site-specific characteristics (e.g., size, sediment, topography) and project requirements (e.g., depth of dredging, state and Federal regulations). Some respondents amplified their remarks, stating that historical data about the general project area and local concern about particular contaminants are important considerations influencing the design of a sediment-sampling plan.

One FOA samples along a transect at fixed distances from the project boundary. Further investigation revealed that the FOA is involved in predominantly maintenance dredging operations, where relatively shallow sediment deposition is common. The project center line is used as a linear reference, and shoals are sampled along a line that is perpendicular to the center line.

Occasionally, FOAs collect samples within a grid overlaid on the project area. Grid sampling results in collecting and analyzing a greater number of sediment samples than is the case with other sampling plans; therefore, it is not routinely used for sediment-sample collection.

Remarks: Although grid sampling is more expensive, its use increases the statistical accuracy of sediment characterization. It is generally used when the sediment to be dredged is suspected to contain high levels of hazardous or toxic substances and precise knowledge of the location(s) and levels of these substances within the project area is desired.

Question: Do written procedures exist for designing and executing a sediment-sampling plan?

Response: Five of the fourteen FOAs polled have written procedures for designing and executing a sediment-sampling plan. Three of these five FOAs use procedures developed by state and other Federal agencies. The other two FOAs developed their own procedural handbooks, incorporating Federal, state, and local guidelines into one comprehensive document.

Remarks: Scientifically based recommendations on the volume of sediment to be represented by one sample and on specific analytical test parameters could lead to a reduction in analytical costs. Such recommendations would add uniformity to the process by which sediment sampling and analysis are planned, organized, and executed.

Question: What method do you use to collect sediment samples?

Response: The most common methods of sediment-sample collection are grab, gravity core, and Vibracore. Twelve of the FOAs collect core samples, and ten collect samples by the grab method. Several FOAs use a remote camera to aid in viewing the sediment surface prior to sampling.

Remarks: Method selection depends on many factors, such as equipment available for collecting samples, depth of sediment to be dredged, type of dredging to be performed (construction versus maintenance), and analytical tests to be performed.

Question: How do you determine sampling depth?

Response: Sampling-depth determination depends on specific situations (6 responses), types of dredging to be performed (5 responses), and sediment-sampling methods used (2 responses). One FOA considers the size of the project to be the primary factor in selecting the depth of sampling. "Situation dependent," "type of dredging to be performed," and "sediment-sampling method used" responses are virtually identical in their meanings: the type of dredging to be performed depends on the project (i.e., the situation), and the sediment-sampling method used depends on the equipment available for sampling and the characteristics of the sediment to be dredged (i.e., the situation).

Question: To what depth do you collect sediment samples?

Response: Most of the FOAs collect samples from the sediment surface or to the proposed dredging depth. Grab sampling is associated with the collection of sediment from the bottom's surface and can also be used to sample to the depth of dredging when the depth of material to be dredged is shallow (<3 ft). Core sampling generally involves sampling of the sediment to the depth of dredging or beyond. Incremental sampling is a variation on the depth-of-dredging method; core samples collected from incremental depths are segregated and analyzed separately.

One FOA uses a standard sampling depth of 4 ft for all of its sediment-sample collections. The reason is due to a mechanical limitation imposed by the sampling instrument: a KB core sampling device that will only penetrate to a depth of 4 ft. Since the FOA is involved primarily in maintenance dredging to relatively shallow depths, a 4-ft core is adequate for characterizing most sediment.

Remarks: Generally, respondents considered the top 4 ft of sediment to be the likeliest strata for locating contaminated material in sediment subject to routine maintenance dredging. The sediment-sampling depth for construction (new work) dredging depends on the depth of dredging to be performed, contaminant history of the area, and the hydrological and sediment-loading factors influencing the project site.

Question: What determines the number of samples collected?

Response: Respondents interpreted this question in two ways: the number of samples taken per sampling station and the number of samples taken from the entire project area. Most said that the number of samples taken depends on the size of the project in cubic yards or its area in square feet and thus a sample represents a specific volume or area of sediment to be dredged. This approach allows FOAs to characterize thin and thick sediment deposits in a like manner. FOAs differ in the volume or area of sediment to be represented by one sample because local and regional requirements influence the volume or area of sediment permitted to be represented by one sample.

Remarks: It is noteworthy that only one FOA responded that the number of sediment samples collected depends on the money available for collection and analysis. Funding limitations apply uniformly to all FOAs and influence the sediment-sample collection and analysis efforts from the project planning phase.

CE cost-reduction efforts should include guidance on the volume of sediment to be represented by an individual sample and the conditions under which that volume should be decreased or increased.

Question: How do you select the method of sample collection?

Response: The method by which samples are collected is strongly influenced by site-specific characteristics of the project, sediment type, and available equipment. Regulatory requirements, sedimentology, site history, and the proposed method of disposal are also determining factors.

Remarks: Specific sediment-testing procedures and testing objectives are important considerations in choosing between grab and core sampling alternatives. Availability of equipment is perhaps the key determinant. FOAs and contractors do not generally have the equipment necessary to conduct sampling by several different methods. In FOAs where no core sampling equipment is available, core samples are simply not taken. The ability to choose the best sampling method results in more accurate characterization and stratification of the sediment profile.

Question: How do you determine the locations of sampling stations?

Response: Several FOAs collect sediment samples at fixed distances from the project boundary or else along a transect of the dredging project center line. Other FOAs divide the project site into segments of similar materials of a specific volume (e.g., 20,000 cu yd of sediment), and samples are collected from stations located within each segment.

Remarks: Stations should be located to provide a good representation of sediment contained within a specific portion of the project area. Generally, stations are selected after careful evaluation has been made of the industrial history of the areas influencing the sediment within the project boundaries. Sediment type influences sampling station location when certain contaminants are of concern. For example, when organic compounds are suspected to exist within the project area, sediment having a significant clay fraction should be sampled more intensively than a sediment that is mostly sand because organics are associated with the fine grained fraction.

Samples are collected at sites located adjacent to a sampling station. In practice, vessels used to collect the samples are positioned on the station, and samples are collected from around the vessel within the range of the working distance of the crane used to maneuver the sampling device.

Sampling at fixed distances from the project boundary or along the project center line usually ignores historical influences, areas of expected sedimentation, and subsurface topography. However, in areas of low contamination or where sediment heterogeneity precludes statistical assessment at a reasonable cost, these methods may be the most effective and cost efficient.

Sampling segments of similar material of a specific volume provides means to identify and isolate material from any segment containing contaminated sediment. The advantage of this method is that the contaminated dredged material can be disposed of separately from clean dredged material, thus reducing the volume of dredged material requiring special disposal management methods and the associated costs of long-term monitoring.

Question: How many samples are collected at each station?

Response: Collection of more than one sediment sample at each sampling station is common. Multiple samples are used to obtain an indication of sediment variability at a station and to avoid the expense and the delay of returning to the project site to collect another sample if the initial sample analysis appears to be erroneous.

Remarks: FOAs not collecting replicate samples at each sampling station should be encouraged to do so because sampling error, sediment variability, or analytical variability may affect the accuracy of analytical results. Replication acts to mitigate the influences of these random errors. One wrong data point could affect dredged material disposal management decisions for sediment represented by a particular sampling station and thus could affect the overall cost of the dredging project.

Replicate samples from each sampling station would not necessarily require complete analysis. In waterways subject to frequent traffic, contaminants can be expected to be homogeneously distributed throughout the sediment surrounding a particular sampling station due to the mixing effects caused by vessels' propellers. Under these circumstances, grain-size analysis might be sufficient to conclude that the samples have like characteristics and that the chemical analysis conducted on one sample would precisely reflect the sediment from which it was extracted.

An alternative to replication is to reduce the volume of sediment represented by each sample. This alternative is likely to result in higher analytical costs, but it produces a better characterization of the sediment to be dredged. Another drawback to this technique is that no indication of the variability of samples at each station is provided.

Question: How many of the sediment samples collected are analyzed?

Response: Nine FOAs analyze all sediment samples collected. Five FOAs archive a portion of the samples collected. Samples archived are replicates, additional samples collected in areas suspected of having contamination, or portions of the original sample not routinely analyzed. When composite samples are used for analysis, portions of the individual samples that made up the composite sample are usually archived. These individual samples can be analyzed later if the results of the composite sample show high levels or questionable types of contaminants. The period of time samples are archived varies and depends on the availability of storage facilities and local practice.

Question: How do you select contaminants of concern?

Response: Selection criteria for analytical tests on sediment samples are generally based on a standard list of contaminants (priority pollutant list) and historical data that may suggest the necessity for other less-routine tests. State regulations impact the analyses required by some FOAs as do recommendations by other governmental agencies.

Remarks: Historical data play a key role in the selection of contaminants to be assayed. Careful review and analysis of the industrial history of the watershed or tributaries of a waterway may raise the expectation of higher levels of certain contaminants in specific areas. If the historical sediment and contamination data of the waterway influencing a project site were reviewed prior to designing the sample collection plan, sampling stations could be adjusted to sample shoals where accumulation of a specific contaminant is most likely.

Question: What types of analytical tests are performed on the sediment samples?

Response: Sediment samples are subjected to a wide variety of tests. Chemical and physical tests are required by all of the FOAs surveyed. The most common analyses performed on the sediments are heavy metals, pesticides, oil and grease, and grain size. Biological testing has been used sporadically by about half of the FOAs. Both animal and plant bioassays are used by those FOAs, with animal bioassays performed more often. Some analytical tests are routinely performed on sediment by some of the FOAs in response to state and local regulations or historical contamination data (Responses 12 and 13, Table 1).

Question: How confident are you that your sampling program accurately characterizes sediment to be dredged?

Response: Most FOAs are confident that collected samples accurately characterize the sediment to be dredged. One respondent stated that he was highly confident in his professional judgement, but not confident in statistical representations.

Question: Do you have any local cost-reduction methods in use?

Response: Half of the FOAs are taking measures to reduce costs associated with sediment sampling and analysis. The other half responded that minimizing costs was standard procedure.

The following lists the cost-reduction methods in use by one or more of the FOAs surveyed:

Doing nonquantified gas chromatography scans and selecting individual compounds to track rather than selecting specific compounds for analysis saves approximately \$100 per sediment sample.

Contracting sediment sampling and analysis results in lower costs because of competitive procurement.

Researching historical data impacting project sites allows for sampling to be conducted at areas that are most likely to be contaminated and thereby reduces the initial number of samples required to characterize the sediment.

Characterizing waterways and harbors based on past sampling and historical data eliminates the need to sample some project sites because adjacent sites having similar characteristics were adequately sampled during a previous dredging project.

Using a tiered approach to testing* to eliminate unnecessary suites of tests of clean material and for early identification of contaminated sediment that will limit disposal alternatives.

Compositing and archiving subcomposites (for later analysis if needed, based on analytical results of composite sample) to avoid possible expense and delay of returning to the project site to collect additional samples.

Conclusions and Recommendations

The survey results suggested several areas wherein sampling and analytical costs may be reduced. The following topics are suggested for discussion at the sediment-analysis cost reduction meeting to be held in FY 87. Recommendations of the meeting will be published in a subsequent technical note.

* N. R. Francine, Jr., et al. 1985. "Management Strategy for Disposal of Dredged Material: Contaminant Testing and Controls," Miscellaneous Paper D-85-1, US Army Engineer Waterways Experiment Station, Vicksburg, Miss.

- Development of criteria for determining the volume of sediment to be represented by one sampling station under a variety of site-specific conditions.
- Development of a computerized system for storage and retrieval of historical contamination data. The system should have a standard entry format and be readily adaptable to all FOA data-processing equipment.
- Review current procedures for and costs of sediment-sample analysis. Determine if contracting for analysis at the national or regional level would be cost effective, responsible, and reliable.
- Review the battery of analytical tests performed on sediment to determine if there are any alternative methods available to obtain the required information at a reduced cost.
- Review use of biological testing. Determine the role of bioassays in sediment analysis and determine whether sampling costs could be lowered through the increased or decreased use of bioassays.
- Develop procedures for determining the accuracy of sample-compositing plans and assess the risks involved with sample compositing.

Table 1. Responses to Sediment Sampling Survey

What types of navigable waters comprise the majority of dredging within FOA's jurisdiction?

Rivers - 14 Harbors - 12 Lakes - 3 Estuarine - 11

What approach do you take to design a sediment-sampling plan?

Site specific - 14 Historical information - 3 Local concerns - 3
Fixed distance between stations - 1 Grid sampling - 1

Do written procedures exist for designing and executing a sediment-sampling plan?

Yes - 5 No - 9

What method do you use to collect sediment samples?

Core samples - 12 Grab samples - 10 Stratified layer sampling - 4

How do you determine sampling depth?

Situation dependent - 6 Type of dredging to be performed - 5
Sampling method used - 2 Size of project - 1

To what depth do you collect sediment samples?

Sediment surface - 11 Depth of dredging - 8
Incremental - 1 Standard depth - 1

What determines the number of samples collected?

Depends on size of the project in cubic yards or its area in square feet - 7
Two to four per site - 2 One per site - 1 Varies depending on project - 1
One per 300 to 400 linear feet - 1 Depends on money available - 1

How do you select the method of sample collection?

Site specific - 4 Regulatory requirements - 2
Sedimentology and site history - 3 Method of disposal - 1

How do you determine the locations of sampling stations?

Representative locations - 8 Industrial history - 6
Sediment type - 2 Fixed distance from boundary - 2
Transect along project center line - 1 Depends on disposal method - 1

How many samples are collected at each station?

Varies with project - 8 One, no replication - 4
Two replicates - 1 Three or four replicates - 2

How many of the sediment samples collected are analyzed?

All samples analyzed - 9 Varies with project - 4 One per station - 1

(Continued)

Table 1. (Concluded)

How do you select contaminants of concern?

Standard list - 8 Site history - 7
Recommendation from other agencies - 3
Fixed group rate - 1 Required by state - 2

What types of analytical tests are performed on the sediment samples?

Entries represent type of test (number of FOAs).

Chemical (14)	Physical (14)	Biological (8)
Heavy metals (10)	Grain size (10)	Animal bioassay (8)
Pesticides (6)	Specific gravity (3)	Plant bioassay (1)
PAHs (3)	Settling rate (4)	
PCBs (5)	Void ratio (1)	
Organics (3)	Total solids (1)	
Oil and grease (7)		
COD (3)		
Phosphorus (2)		
Ammonia (2)		
DDT (2)		
TOC (6)		

How confident are you that your sampling program accurately characterizes sediment to be dredged?

Highly confident - 3 Confident - 8
Fairly confident - 3 Not confident - 1

Do you have any local cost-reduction methods in use?

Yes - 7 No - 7

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